

# **System Integration and Performance of the EUV Engineering Test Stand**

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## **Outline**

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- Overview of EUV Engineering Test Stand design
- Accelerated schedule
- Subsystem performance
- Progress in ETS integration
- Summary



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## Engineering Test Stand high level schedule

✓ Concept design	Q4 97
✓ Final design and modeling	Q4 98
✓ Subsystem module testing	Q4 99
✓ Subsystem integration	Q2 00
Illuminator-main chamber integration	
First EUV operation	Q3 00
	Q2 01

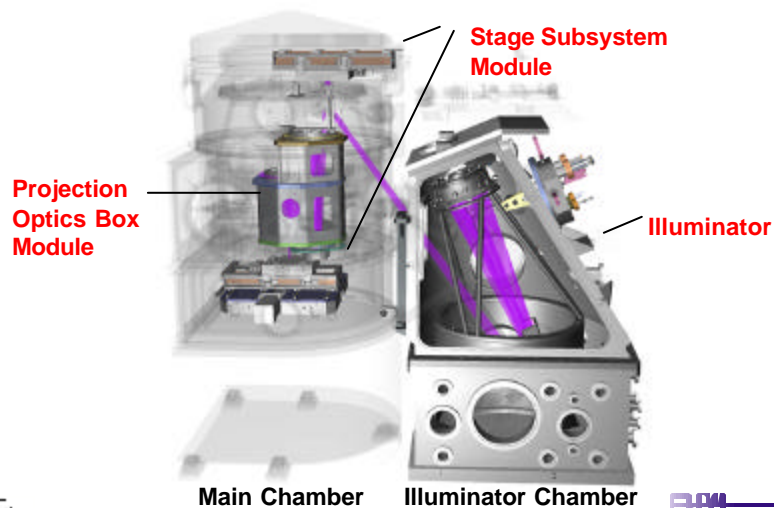


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## Engineering Test Stand consists of three major subsystems



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## New plan implemented to accelerate ETS and demonstrate full field imaging

- Integrate ETS with developmental optics set 1 to demonstrate fully integrated machine performance and full field scanned images by April 2001
- In parallel, demonstrate static imaging over a limited field area at LBNL using improved optics set 2
- Transfer optics set 2 to ETS after qualification complete

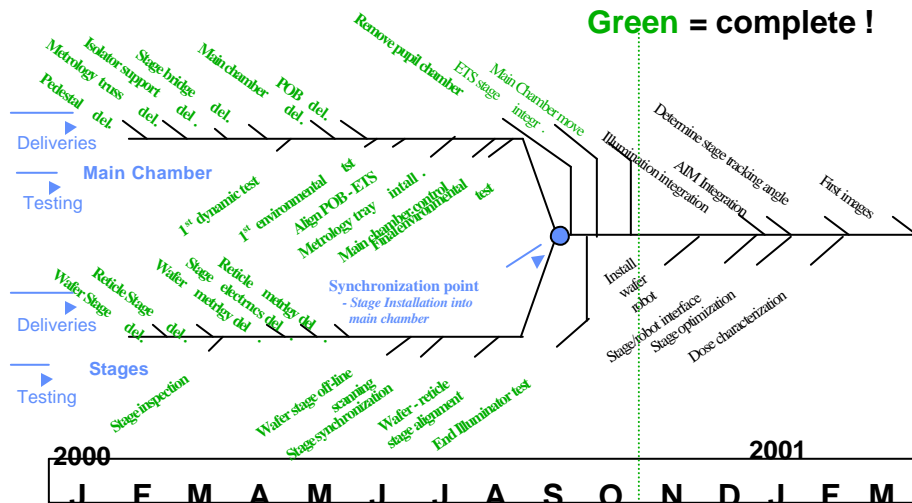


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## Accelerated ETS schedule and progress

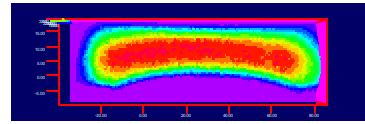


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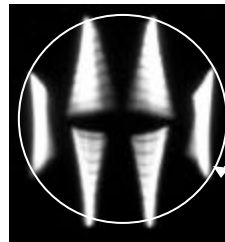
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## EUV illumination has been measured in the reticle plane and pupil



Reticle illumination



0.7 pupil fill

Pupil illumination



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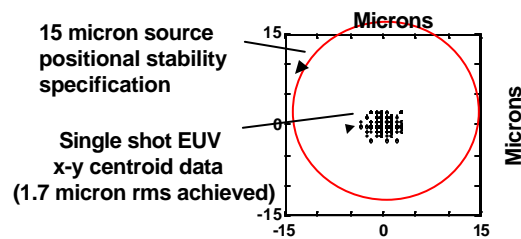
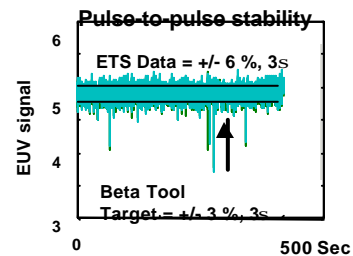
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## ETS illuminator has been used for source testing prior to integration with main chamber

- EUV pulse stability meets dose requirements for ETS
- Source position control much better than target specification
- No reflectance loss yet observed for C1 during limited operation



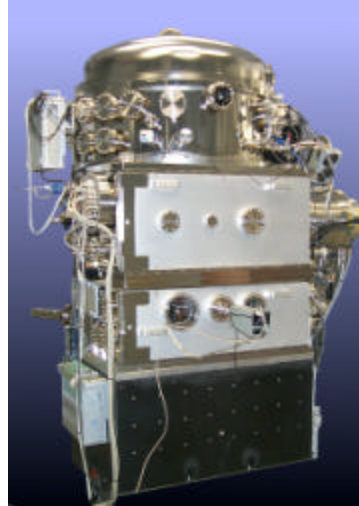
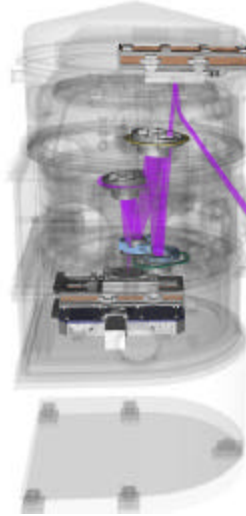
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## Main chamber assembly has been completed



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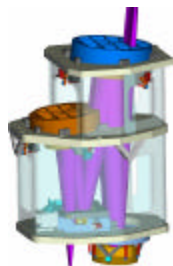
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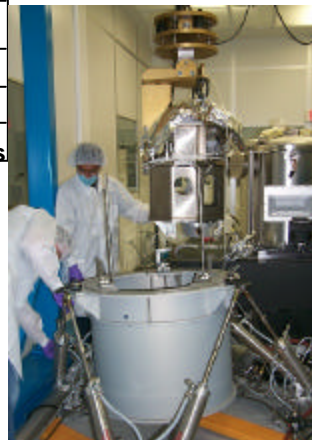
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## Two complete optical systems have been fabricated for the ETS

	Specifications	
	Optics Set 1	Optics Set 2
Surface figure	$<0.50\text{nm rms}$	$<0.25\text{nm rms}$
Mid-spatial freq.	$<0.50\text{nm rms}$	$<0.20\text{nm rms}$
High-spatial freq.	$<0.40\text{nm rms}$	$<0.10\text{nm rms}$



PO Box 1



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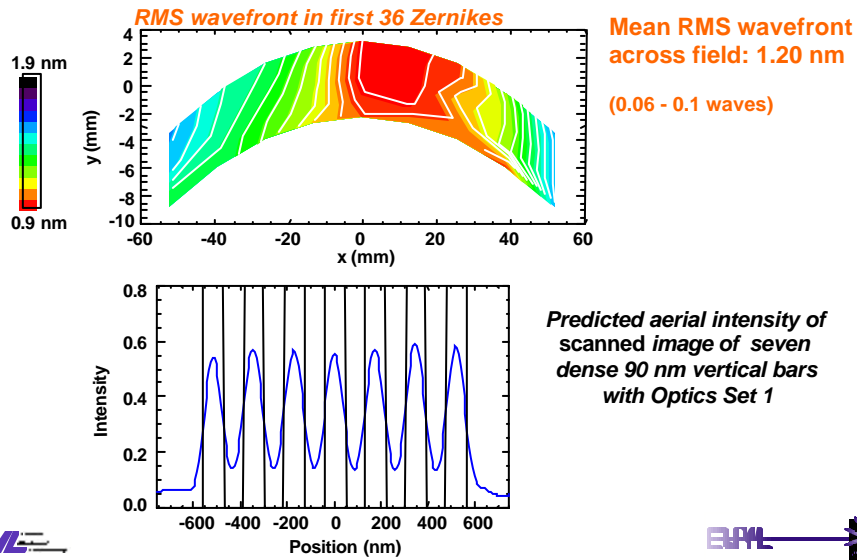


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The aligned Optics Set 1 has an rms wavefront error that varies from 0.06 to 0.1 waves across the field



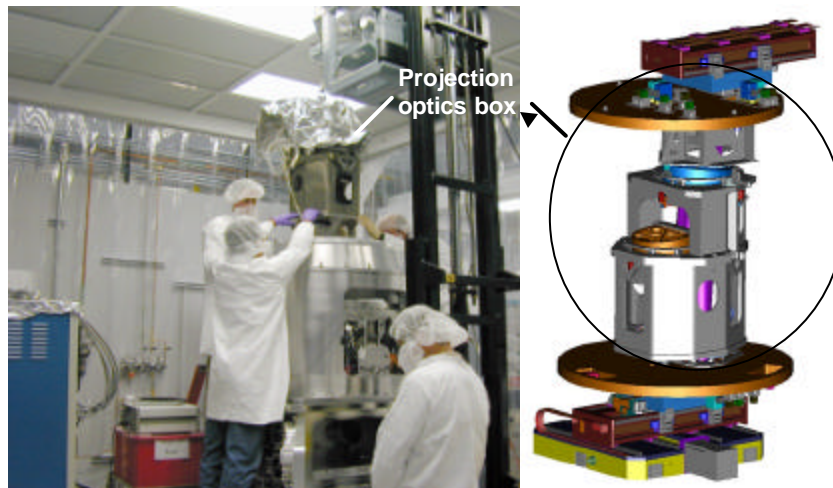
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**PO Box with optics set 1 is integrated in the main chamber**



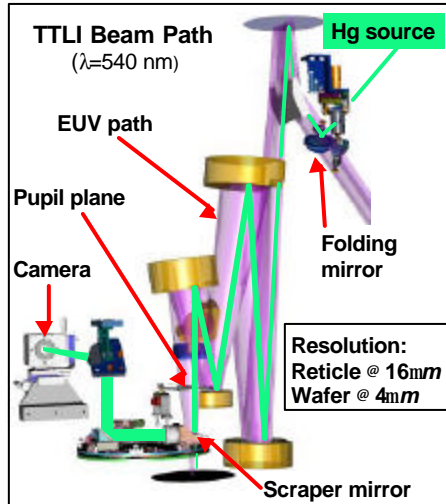
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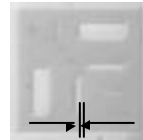


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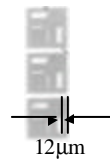
## Visible light through-lens images verify system alignment



6mm illumination spot at the mask plane from a mercury arc lamp



TTL image of a patterned reticle, 1mm cell



TTL image of the patterned wafer, 100mm cells



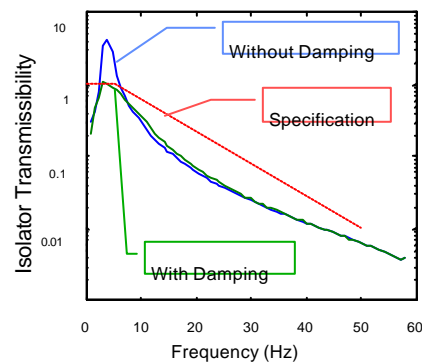
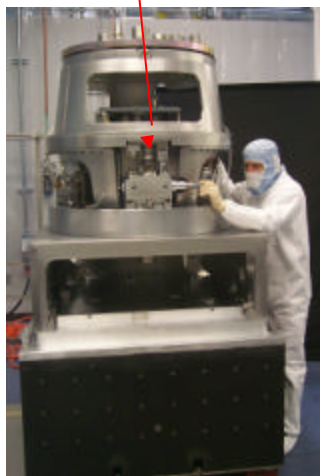
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## Vibration isolation system meets specifications for first light

Isolator

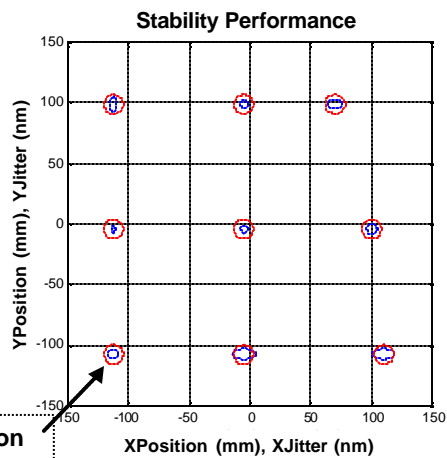
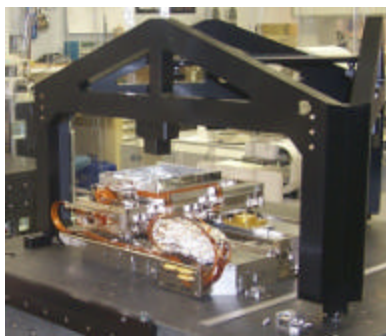


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## Wafer stage meets positional stability performance specification on test station



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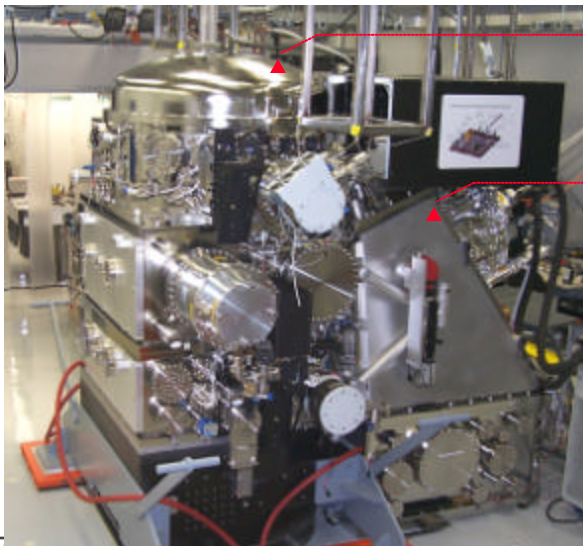
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## The Main Chamber Assembly has been aligned to the Illuminator



Main Chamber Assembly

Illuminator



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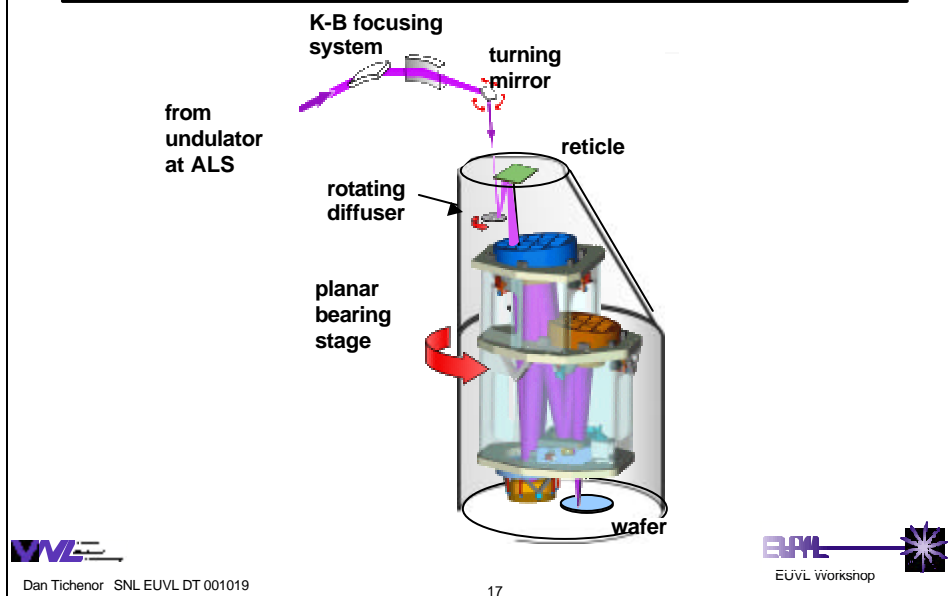
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## Static imaging tests will be used to demonstrate wavefront quality of optics set 2



## ETS contamination mitigation strategies

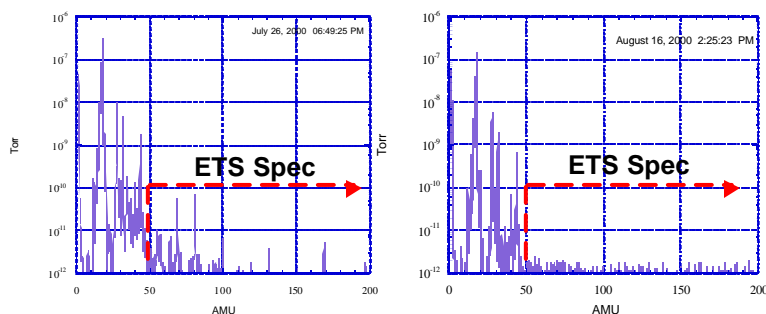
- Pre-qualify vacuum compatible components for low outgassing properties
  - 249 components tested to date
- Establish and manage three separate protection zones within tool (reticle zone, optics zone, and wafer zone)
- Use gas blend approach to keep optics clean during EUV operation
- Develop backup in situ ML cleaning procedures for carbon deposits

## Excellent control of hydrocarbons has been achieved in fully assembled Main Chamber

### RGA Scans

Illuminator

Main Chamber



Specification: <10<sup>-10</sup> torr for AMU greater than 44



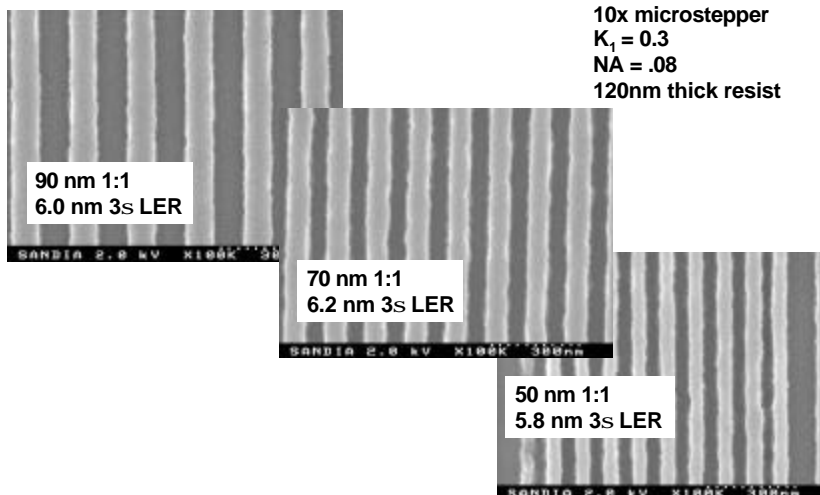
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## Printing of dense 1:1 features has been extended to 50nm using off-axis illumination



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## Summary

- ETS schedule pulled in 6 months, and integration on track for April 2001 imaging milestone using optics set 1.
- Optics set 2 complete for static exposure demonstration in 3Q 2001.
- Contamination mitigation strategy identified - ETS meets vacuum environment specification.
- 10x microstepper imaging extended to 50nm for resist and mask development.

